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# DAYTIME SLEEPINESS, PERFORMANCE, MOOD, NOCTURNAL SLEEP: THE EFFECT OF BENZODIAZEPINE AND CAFFEINE ON THEIR RELATIONSHIP

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**Daytime Sleepiness, Performance, Mood, Nocturnal Sleep:  
The Effect of Benzodiazepine and Caffeine on Their Relationship**

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## SUMMARY

### Introduction

Daytime sleepiness is not only a clinical and research problem, it can have serious consequences in operational settings. Sleepiness and alertness are generally viewed as reciprocal and have been viewed as a function of the circadian cycle and of prior sleep and wakefulness.

It has been clearly established that total or partial sleep loss results in decreased alertness and impaired performance, but the magnitude of the relationship between sleepiness and performance decrement has not been determined. Furthermore, there is conflicting data as to whether objective measures of sleepiness, such as the EEG based multiple sleep latency test, are better predictors of performance and mood than are the more easily obtained subjective estimates of sleepiness, such as the Stanford Sleepiness Scale. Further, in the nonsleep deprived subject there is conflicting data on the relationship of amount and quality of nocturnal sleep to daytime sleepiness. With the increasing use of hypnotics to induce sleep and stimulants to maintain alertness, the question arises as to whether these drugs influence the relationship among sleep, performance, and mood.

This study further examined the relationships between daytime sleepiness, performance, mood and nocturnal sleep and how these relationships were influenced by the nighttime use of a benzodiazepine and ingestion of caffeine in the morning.

### Method

In a double-blind parallel group design, 80 young adult males were divided into eight treatment groups. Subjects received 15 or 30 mg of flurazepam, 0.25 or 0.50 mg of triazolam, or placebo at bedtime, and 250 mg of caffeine or placebo in the morning for two treatment days. Two objective (Multiple Sleep Latency Test and lapses) and two subjective (Stanford Sleepiness Scale and Visual Analog Scale) measures of sleepiness, five performance tests, and two mood measures (Profile of Mood Scale and Visual Analog Scale) were administered repeatedly on both days. EEG sleep was recorded on both nights.

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## RESULTS

Objective measures of daytime sleepiness were not significantly related to either performance or mood though those with greater sleep tendency generally reported better mood. Subjects with greater daytime sleep tendency had significantly longer and more efficient nocturnal sleep. Neither benzodiazepine or caffeine influenced these relationships. In contrast, higher subjective estimates of sleepiness were significantly associated with poorer mood and tended to be related to poorer performance. Subjects receiving caffeine did not show these relationships. Nocturnal sleep measures were not related to subjective estimates of daytime sleepiness.

## Conclusions

Objective measures of sleepiness in nonsleep deprived, nonclinical subjects are not as good predictors of mood and performance as are subjective estimates. In our subjects, the ability to fall asleep quickly is not necessarily a reflection of pathological sleepiness and is not due to poor nocturnal sleep or, in most instances, associated with poor performance. Objective and subjective measures appear to sample different aspects of sleepiness in the nonsleep deprived subject, but with sleep loss, results from objective and subjective measures should become more similar. Caffeine can be used to reduce the association of subjective sleepiness with poorer mood.

Daytime sleepiness is receiving increased attention in both the clinical and research areas and an average sleep latency of less than five minutes on the widely used Multiple Sleep Latency Test (MSLT) is generally accepted as indicative of pathological sleepiness (1). Sleepiness and alertness are generally viewed as reciprocal, and as a function of the circadian cycle and of prior sleep and wakefulness (2).

The relationship of nocturnal sleep to performance and mood has long been an interest of sleep researchers, but as Roth et al. (3) noted, interest has shifted to the correlates of daytime sleepiness as its measurement has become more objective and clinically relevant. Clearly, with sleep deprivation, partial or total, daytime sleepiness increases and performance and mood deteriorate as sleep loss increases (4). Dement and Carskadon's belief that daytime sleepiness is a function of prior sleep and wakefulness was based primarily upon studies of sleep loss (5,6,7,8,9,10) and extended sleep (11). Group statistics indicated that as nocturnal sleep decreased, daytime sleepiness increased and when sleep was extended, the reverse was found. However, when seven indicators of amount and quality of sleep were correlated with MSLT only stage 1 time showed a moderate, -.36, but significant relationship in their sample of six young adults over seven nights of sleep (8).

To the surprise of many sleep researchers, subsequent studies have shown that greater total sleep time (TST) and better quality of nocturnal sleep are associated with greater daytime sleep tendency in insomniacs (12,13,14) and in non insomniacs (15,16). Sugarman et al. (13) did not report correlational data, but they found that while the objective insomniacs had poorer nocturnal sleep, the MSLT sleep latencies (SL) were shorter for the subjective insomniacs whose night-time sleep was not impaired.

Although it has been commonly observed that, following sleep loss, daytime sleepiness coexists with decreased performance, there have been few studies that have correlated the two. Following one night of total sleep deprivation, Glenville and Broughton (17) found that the Stanford Sleepiness Scale (SSS) significantly predicted performance decrement. But after five nights of partial sleep deprivation (-40% from baseline), the correlation between SSS and performance was not significant even though group SSS scores increased and performance decreased during the deprivation period (18). We know of no similar MSLT studies.

The MSLT, however, has been used in studies of non sleep deprived normals and insomniacs. Seidel et al. (12) found a moderate, but significant, negative correlation between MSLT latency and card sorting by value in a sample of 78 noncomplaining sleepers, but no significant correlation was found in 105 insomniacs. Sugarman et al. (13) reported that the correlation between MSLT and performance on an auditory vigilance task did not reach statistical significance in their sample of 16 insomniacs and 8 normals. In another study (16), sleepy subjects, MSLT  $\leq 6$  mins, performed significantly worse than did 12 alert subjects, MSLT  $\geq 16$  mins, on a divided attention task but not on a vigilance task. The relationship between subjective measures of sleepiness, such as the SSS, and performance were not reported in these studies.

While daytime sleepiness is a concern of both sleep apneic and narcoleptic patients, controlled studies relating measures of sleepiness to performance are rare. In a well controlled study, Valley et al. (19) compared narcoleptics and matched controls on a battery of performance tests while obtaining repeated SSS measures. Narcoleptics showed poorer performance on a 1-hour vigilance task, and on a 10 min 4-choice reaction time test, but not on the shorter, more rapidly paced auditory serial addition task and digit span. There were no significant correlations between the SSS scores and any of the performance measures.

The effects of benzodiazepines and caffeine are well known. At some dose levels, the benzodiazepines produce next day drowsiness and impair performance (20). Caffeine, in contrast, increases alertness and enhances performance when it has been degraded by fatigue or sleep loss (21). In this study, in addition to further examining the relationship between daytime sleepiness, performance, mood and nocturnal sleep, we also investigated how these relationships were influenced by the nighttime use of a benzodiazepine and the ingestion of caffeine in the morning.

#### METHOD

##### Subjects:

Subjects (Ss) were 80 healthy young adult male volunteers, mean age  $20.3 \pm 2.74$ , from the San Diego Naval School of Health Sciences. Ss were studied in pairs. Both Ss in a pair received the same treatment. Two pairs were replaced because of non-study related illness of one of the pair, and one pair was replaced because they were allowed to eat a much

larger breakfast than called for in the protocol. Ss were nonsmokers and consumed no more than three cups of caffeinated beverage per day.

Subjects completed a health and sleep questionnaire, and only good sleepers were selected as the goal of this study was to evaluate next day behavior and not hypnotic efficacy. Interviews were conducted to ensure reliability of the questionnaire data and to explain the study. Urine and breathalyzer tests showed that all Ss were drug-free.

**Treatments:**

The 80 subjects were randomly assigned in equal numbers to one of eight groups in a parallel-group, double-blind design. Each group received similar capsules at 2145 h and 0515 h for two days. The evening and morning medications and dosages for the eight groups are listed in Table 1. The groups received the same treatment on both days.

**Table 1. Treatment groups**

Group	Evening	Following Morning
PP	Placebo	Placebo
PC	Placebo	Caffeine
LTRZP	0.25 mg Triazolam	Placebo
HTRZP	0.5 mg Triazolam	Placebo
HTRZC	0.5 mg Triazolam	Caffeine
LFLZP	15 mg Flurazepam	Placebo
HFLZP	30 mg Flurazepam	Placebo
HFLZC	30 mg Flurazepam	Caffeine

### Measures of Sleepiness:

Four measures of sleepiness were obtained during the day following each treatment night: two objective, MSLT and lapses, and two subjective, SSS and Visual Analog Scale (VAS).

MSLT: Sleep latency was defined as the minutes from lights out to the appearance of the first sleep spindle, K-complex or rapid eye movement (REM) sleep. Technicians were instructed to terminate the test one min after sleep occurred and the test was ended after 20 min if sleep had not occurred. All MSLTs were scored blind by the first author.

Lapses: This was a 10-min tapping task, five minutes with eyes closed, five minutes with eyes open. The S was instructed to relax but stay awake and to tap at a comfortable rate on a key beside his bed. The S was sitting up in bed. A lapse was scored when the time between taps was longer than three secs. Technicians were instructed to remind the S to keep tapping when a 5-10 sec pause occurred. The number of lapses in the 10-min period was used as a measure of sleepiness. This task is a measure of the Ss' ability to remain awake and, in that respect, is similar to the Maintenance of Wakefulness Test (MWT) of Mitler et al. (22).

SSS-VAS: The subjective estimates of sleepiness were the SSS (Hoddes et al. 1973) and a 100 mm visual analogue scale (VAS) which was administered along with 8 other scales measuring various moods (23). On the VAS, the S was requested to draw a vertical line between very alert on the left end and very sleepy at the right end. The VAS score was measured in mm from 0 to 100. The SSS has seven steps ranging from (1) 'Alert, Wide Awake' to (7) 'Almost Asleep.' These measures were obtained before each MSLT.

### Performance Tests:

The performance test battery included: 1) the Wilkinson 4-choice reaction time (CRT), 11 min, 2) digit symbol substitution test (DSST), 90 s, 3) card sorting by color, suit, and value, 4) short and long term memory, and 5) a paired-associate learning task.

For the short-long term memory task, Ss heard a tape-recorded list of 15 words and wrote down each word. At the end of the 15-word presentation, the S had two minutes to write down as many words as he could recall. A new list was given at each testing. Before the presentation of words for trial 4 at 1700 h, the S was first asked to recall the 45 words presented on the three previous trials and then to recognize the previously heard words from



a list of 90 words. For the paired associate task, the S learned 10 word-pairs from a tape-recorded list. Prior to learning a new pair of 10 words on trials 2, 3 and 4, the S was asked to recall the associates of the stem words given on the preceding trial. Two minutes were allowed for this recall. Prior to trial 4, the S was allowed two minutes to match the stem word from lists 1, 2, and 3 with their associates from a list of the previously presented associates.

Both computer and paper-pencil format was used. The CRT, short-term memory recall, and long-term memory recognition were presented by computer, the others by paper-pencil. The scores analyzed were mean RT for correct responses on CRT; total time in seconds required to complete the card sorting; the number correct on the DSST; the number correctly recalled and the number correctly recognized on short-term and long-term memory; and the number correctly recalled and the number correctly recognized on paired associates.

#### Mood Measures:

Mood was evaluated by the POMS and the 9-item Visual Analog Mood Scale (23). The item "how sleepy do you feel?" was omitted in computing the total VAS mood score. The score for each item was the distance in millimeters (mm) marked from the left end of a 100 mm line. Both the VAS mood items and the POMS scales were scored so that a high score reflected a more negative mood.

#### Procedure:

Pairs of Ss spent two-and-one-half days and two nights in the laboratory. All meals were provided and no caffeinated beverages were allowed. Breakfast consisted of orange juice, milk, and two pieces of buttered toast. Breakfast was at 0930 h, lunch at 1330 h, and the evening meal was at 1730 h. The late breakfast was to minimize the possible effect of food on caffeine in the early morning tests. In most instances, Ss reported to the laboratory around 1300 h on Monday. At that time, they received detailed information about the study and study procedures and signed an informed consent statement. A pretreatment training session was then conducted on all the cognitive and psychomotor tests, and Ss were given an MSLT, usually between 1530-1630 h. Bedtime on each evening was 2150 h (lights out at 2200 h) and morning awakening was at 0500 h both days. The nighttime capsule was

given at 2145 h and the morning capsule was administered at 0515 h. Testing times for the sleep, performance, and mood variables are listed in Table 2.

Table 2: Testing schedule: Day 1 - Day 2

MSLT-VAS-SSS	LAPSES (TAPPING TASK)	PERFORMANCE-MOOD
0700	0600	0730
0900	1000	1130
1100	1400	1530
1300		1930
1500		
1700		

#### Statistical Analysis:

The relationships between variables were measured by use of Pearson product moment correlations. All p values were two-tailed and because of the number of comparisons made, a p value of .01 was used for significance. To further guard against type 1 errors, consistency of relationships was stressed. Isolated  $p < .01$  correlations are presented but less weight is given to these relationships in the discussion.

An earlier analysis of these data revealed a significant relationship between the two objective and between the two subjective sleep measures but no significant relationship between subjective and objective measures (24). We also found that the objective sleep measures were more sensitive to treatment effects than the subjective measures (25). Therefore, separate composite scores were calculated based on the objective sleepiness measures and on the subjective sleepiness measures. The MSLT score, 20 minus the actual SL, was combined with the total number of lapses for the objective sleep score, so that a high score indicated greater sleepiness. For subjective sleepiness, SSS and VAS scores were combined. Again, a high score

indicated greater sleepiness. A composite performance score was calculated from the subject's mean performance on all the tests. Each test was scored so that a high score indicated better performance. Similarly, composite mood scores were computed for the VAS (mood) and POMS values. All items on the mood scale and individual subscales of the POMS were scored so that a high score indicated a more negative mood. Performance and mood were also related to the two composite sleep scores. They were also related to each of the four sleep measures, but only the MSLT results are presented in detail since this measure is widely used as the standard for determining sleep tendency. Lapse results were similar to that for MSLT and the two subjective measures were similar to each other and to the composite subjective sleepiness measure. Finally, as two nights of nocturnal sleep were available, measures of nocturnal sleep quality were correlated with daytime sleepiness, performance, and mood.

## RESULTS

### Mood and Performance:

The two mood measures were, as expected, always significantly correlated. The focus of our analysis was not on the relationship of mood to performance, but these results were available. There were no significant relationships, whether total score, day 1 or day 2 scores, or individual trial results on each day were compared.

### Sleepiness, Performance and Mood:

The correlations of daytime sleepiness with performance and mood are listed in Table 3. Data have been summed over all groups (n=80). Objective sleepiness (MSLT + lapses) was not significantly correlated with either performance or mood on either day. Subjective sleepiness (SSS + VAS) was significantly associated with more negative mood (both composite measures) on both days and with poorer performance on day 1, but not on day 2. Examination of the individual items on the VAS (mood) indicated that the more sleepy subjects rated themselves as significantly less calm, more tense, and more weary, and said the tasks required more effort. On the POMS, subjective sleepiness was significantly correlated with fatigue and confusion scale scores. Vigor was negatively correlated but only at the  $<.05$  level. Although statistically significant, the correlations were of moderate magnitude, .30 to .40. It is of interest, although nonsignificant, that the direction of the relationship between objective sleepiness and mood

was in the opposite direction to that of subjective sleepiness and mood. Higher daytime sleep tendency was associated with more positive mood on both VAS (mood) and POMS. On the VAS (mood), the relationship between calm and sad approached significance ( $p < .05$ ), i.e., subjects with high objective sleepiness rated themselves as more calm and less sad.

**Table 3:** Correlation of objective and subjective measure of sleepiness with performance and mood; N=80.

<u>Sleep Measures</u>	<u>Performance</u>	<u>VAS (mood)</u>	<u>POMS</u>
<b>Day 1</b>			
Objective	.01	-.07	-.15
Subjective	-.32**	.47**	.36**
<b>Day 2</b>			
Objective	-.01	-.24	-.12
Subjective	-.17	.41**	.31**

\*\* $p < .01$

**Effect of Treatment:**

The two hypnotics and the different dose levels showed similar and nonsignificant effects, so the groups were combined into hypnotic-placebo, N=40 (PM hypnotic, AM placebo) and hypnotic-caffeine, N=20 (PM hypnotic, AM caffeine). The placebo-placebo (PM placebo, AM placebo) and placebo-caffeine (PM placebo, AM caffeine) both had Ns of 10. Results of analysis for these treatment groups are presented in Table 4. The correlations for the groups receiving caffeine are in parentheses.

**Table 4: Effect of treatment on relationship of sleep measures with performance and mood**

**Day 1 Groups: Placebo-Placebo and Placebo-Caffeine (Parenthesis)**

<u>Sleep Measures</u>	<u>Performance</u>	<u>VAS (mood)</u>	<u>POMS</u>
Objective	.16 (-.17)	.19 (-.17)	-.28 (.01)
Subjective	-.43 (-.43)	.77** (.09)	.65 (.53)

**Groups: Hypnotic-Placebo and Hypnotic-Caffeine (Parenthesis)**

Objective	.16 (.31)	-.19 (-.26)	-.04 (-.46)
Subjective	-.07 (-.49)	.55** (.25)	.47 (.09)

**Day 2 Groups: Placebo-Placebo and Placebo-Caffeine (Parenthesis)**

<u>Sleep Measures</u>	<u>Performance</u>	<u>VAS (mood)</u>	<u>POMS</u>
Objective	.10 (-.19)	-.30 (-.32)	-.26 (-.33)
Subjective	-.20 (-.38)	.44 (.19)	.25 (.63)

**Groups: Hypnotic-Placebo and Hypnotic-Caffeine (Parenthesis)**

Objective	.17 (.15)	-.30 (-.31)	-.06 (-.29)
Subjective	-.04 (-.33)	.64** (.11)	.53** (-.15)

**\*\* -  $P < .01$**

**P-P N=10**

**P-C N=10**

**H-P N=40**

**H-C N=20**

As in the total sample, objective sleepiness was not significantly associated with performance or mood on either day in any treatment group. Subjective sleepiness showed a significant positive correlation with both mood measures on both days in the hypnotic-placebo group. Receiving caffeine in the AM abolished the significant relationship between sleepiness and mood. Although consistently negative, the correlation between subjective sleepiness and performance was not significant for any group.

In the placebo-placebo group only one correlation, that between subjective sleepiness and VAS (mood), was significant, and only on day 1. This correlation was not significant in the placebo-caffeine group.

#### Analysis Over Trials:

Except for trial 4, the late afternoon trial, objective sleepiness was not associated with either mood or performance. On trial 4, subjects with higher sleep tendency had significantly lower (better) mood scores (POMS day 1,  $r = -.36$ ; day 2,  $r = -.32$ , VAS (mood) day 2,  $r = -.51$ ). Examination of individual subscales of the POMS showed that high sleep tendency was significantly associated with lower scores on confusion and fatigue on both days and with lower anger and tense scale scores on day 1. On VAS (mood), high sleep tendency was correlated with low sadness, both days, and with lower tenseness, less effort, more happy, more calm ratings on day 2.

Subjective sleepiness, on the other hand, showed a significant positive association with both mood measures on all trials except trial 4. On day 1, trial 4 subjective sleepiness was not correlated with either mood measure. On day 2, it was positively associated with VAS (mood) but not POMS. In contrast to objective sleepiness, the more sleepy subjects received higher, more negative, mood scores, i.e., more fatigued, tense, weary, and less calm. Neither objective or subjective sleepiness was significantly correlated with performance in any trial on either day.

#### Effect of Treatment:

As the correlation between objective sleepiness and mood occurred in the late afternoon trial 4, treatment should have had little effect on these correlations and none was found. For subjective sleepiness, caffeine had the effect on individual trials that was seen for the whole day averages. While the hypnotic-placebo group correlations were significant on all trials on both days, except trial 4, none of the correlations for the hypnotic-caffeine group was significant. There were also no significant correlations

between subjective sleepiness and mood for the placebo-caffeine group. The placebo-placebo pattern was similar to that for the total group, with moderate correlations between subjective sleepiness and both mood measures. However, due to the small N, a very high correlation (.71) was required for the  $p < .01$  level of significance. Only three of the correlations reached or exceeded this level.

**In summary:** A consistent pattern emerged over days and over trials. Our objective measure of sleepiness was not significantly related to daytime performance or mood and neither caffeine or hypnotics influenced the relationship. In contrast, for the subjective measure, greater sleepiness was significantly related to a more negative mood and, to a lesser degree, to poorer performance. Groups who received caffeine in the mornings showed no significant relationships.

#### NOCTURNAL SLEEP - DAYTIME BEHAVIOR

The analysis of nocturnal sleep for this report was concerned primarily with quality of sleep. Five variables were examined: TST, sleep efficiency (SE), time stage 1 (TS1), total wake time (TWT), and latency stage 2 (LAT2). Because of the general interest in the functions of stage REM and stages 3 and 4 (SWS), we also examined the relationship of percent time in these two types of sleep to our daytime measures. The means, SDs and range for these variables are listed in Table 5. As our subjects were selected for good sleep, intersubject sleep was more homogenous than that for a sample of poor sleepers. However, the range for each variable indicated that some of our sleepers had poor sleep on one or both nights.

#### Relationship to Mood and Performance:

Neither percent time in Stage REM or in SWS was significantly related to daytime performance or mood, and none of the quality of sleep measures was related to daytime performance. LAT2 was positively correlated with mood on day 1 (POMS  $r = .37$ , VAS (mood)  $r = .37$ ). There were no significant correlations between nocturnal sleep and mood on day 2.

#### Nocturnal Sleep-Daytime Sleepiness:

None of the nocturnal sleep measures were significantly related to subjective estimate of daytime sleepiness. LAT2 on night 1 was significantly related to objective sleepiness ( $r = -.34$ ). The reader should remember that the objective sleep measure (MSLT + Lapses) was scored so that a high score indicated more sleepiness. Thus, our negative correlations indicated that

the more quickly a subject went to sleep at night, the higher his sleep tendency was during the day. TST, SE, TS1, and TWT were also related to objective sleepiness on day 1 but only at the  $p < .05$  level. In each instance better sleep at night was associated with greater daytime sleep tendency.

Table 5: Characteristics of sleep for total sample N=80

<u>Sleep Variable</u>	<u>Night</u>	<u>Mean</u>	<u>SD</u>	<u>Range</u>
TST (mins)	1	399	12.5	332-414
	2	399	12.4	342-414
SE	1	94.9	2.9	78.8-98.2
	2	94.7	3.0	81.2-98.5
TS1 (mins)	1	8.2	6.5	1.0-42
	2	8.3	6.8	0.5-35
TWT (mins)	1	7.6	7.1	.5-36
	2	8.3	8.3	1.5-58
LAT2 (mins)	1	7.2	3.8	1.0-21
	2	8.3	5.5	1.0-31
SRGM (%)	1	21	7.2	5.0-36
	2	23	5.8	7.0-37
SWS %	1	19	9.3	0.0-38
	2	18	8.5	0.0-34

On night 2, TST, SE, LAT2, and TWT were significantly correlated with day 2 objective sleepiness. The correlations were .35, .36, -.45, -.37, respectively. Again, the better the nighttime sleep, the higher the objective sleepiness value.

#### Effect of Treatment:

The hypnotics produced some of the expected changes in sleep, i.e., increased TST, SE, decreased TS1, LAT2, TWT, but in this sample of good sleepers these changes were small and only the decreases in TS1 was significant. Examination of individual treatment groups indicated that treatment did not have a significant influence on the correlation between nocturnal sleep and daytime measures of sleepiness.



### The MSLT:

We first examined the relationship of MSLT (SL) to daytime behavior and nocturnal sleep. We then selected a sub sample of 'pathologically sleepy' subjects with an average SL over both days of  $<5$  mins ( $N=20$ , mean SL  $4.01 \pm 6.74$ ). We contrasted this sample with a group whose average SL was greater than 10 mins ( $N=24$ , mean  $14.2 \pm 2.64$  mins). A t-test for independent means was used to test for significant differences between these two groups.

### Correlational Data:

SL was not correlated with performance or either mood measure on either day. SL, however, was correlated with nocturnal sleep on both nights. TST was significantly negatively correlated with SL,  $r = -.31$  night 1 and  $r = -.39$  night 2. In this analysis, SL was scored and interpreted in the usual manner. Thus, a higher TST was associated with shorter SL. SL was positively correlated with TWT, and LAT2. The respective correlations were .29, .47, night 1; .32, .49, night 2. The correlation of TSI with SL reached the  $p < .05$  level for night 1,  $r = .26$ , but did not approach significance on night 2.

### Low MSLT vs High MSLT:

As was expected from our previous finding of a significant correlation between MSLT and number of lapses ( $r = .51$   $p < .001$ ) (23), the high MSLT group had significantly fewer lapses than the low MSLT Ss. The respective means  $\pm$  SD were  $2.2 \pm 2.40$  and  $8.3 \pm 4.47$ ,  $t=5.84$ ,  $<.001$ . The two groups did not differ significantly on the two subjective measures of sleepiness, SSS and VAS.

The two groups also did not differ significantly on the composite performance measure or on any of the individual performance tasks. The same was true for the composite POMs score and for each of the individual POMs scales, although the trend was for the low MSLT subjects to have lower, more positive, mood scores. On the composite VAS (mood) score, group difference approached significance ( $p < .04$ ). For one VAS (mood) scale, tense, the difference was significant ( $p < .001$ ) and for another, effort, it approached significance ( $p < .05$ ). The low MSLT subjects were less tense and said the tasks required less effort than did the high MSLT subjects.

The data in Table 6 indicate that these two groups differed significantly with respect to quality of sleep but not in the percent of REM or SWS. The low SL subjects had more TST, higher SE, less stage 1, less TWT and a

shorter latency to stage 2. This pattern was similar on both nights but the group differences tended to be larger on the second night. The intersubject variability was higher for the high MSLT subjects on the quality of sleep variables.

**Table 6:** MSLT and Nocturnal Sleep, Low MSLT had average SL of <5 mins over both days; N=20. High MSLT average SL was >.10 min; N=24.

<u>Sleep Variable</u>	<u>LOW/MSLT</u>		<u>HIGH/MSLT</u>		<u>P Value</u>
	<u>Mean</u>	<u>SD</u>	<u>Mean</u>	<u>SD</u>	
TST	403.8	+ 4.6	391.2	+ 14.5	3.70***
SE <sup>+</sup>	96.0	+ 1.1	93.1	+ 3.4	3.70***
TS1	6.1	+ 3.2	10.7	+ 8.8	2.16
TWT	5.1	+ 2.9	12.4	+ 8.4	3.70***
LAT2	5.7	+ 1.7	10.3	+ 4.7	4.20***
REM <sup>+</sup>	82.7	+ 24.8	87.2	+ 22.1	0.63
SWS <sup>+</sup>	78.4	+ 29.6	60.0	+ 35.0	1.86

\*\*\* P<.001

<sup>+</sup> SE, REM and SWS are %s, others are shown in minutes

In Summary: SL, as measured by the MSLT, was not related to performance or mood but was related to quality of nocturnal sleep. Subjects with shorter SL had better sleep. Similar results were obtained when groups of 'pathological' and 'non pathological' sleepers were compared. The 'pathological' sleepers slept better at night but did not differ from 'non pathological' subjects on daytime performance or mood; although those with low SL tended to be less tense and needed to exert less effort.

#### DISCUSSION

In this sample of young adult good sleepers, objective sleepiness as measured by SL on the MSLT and lapses on a tapping task was not significantly related to daytime performance or mood, though subjects with higher sleep tendency tended to have better mood. Higher sleep tendency was associated with higher TST and SE. When the MSLT was examined separately, we found little support for the belief that a SL of <5 min was indicative of 'pathological' sleepiness as these subjects did not differ from subjects with a SL of >10 min. in performance or mood but the longer SL subjects had

less TST and poorer quality of nocturnal sleep. Neither bedtime benzodiazepines or morning caffeine significantly influenced these relationships.

In marked contrast, a subjective estimate of sleepiness, derived from the SSS + VAS, was significantly related to mood and marginally related to performance. Greater sleepiness was associated with poorer mood and performance. When caffeine was administered in the morning, there were no significant correlations between subjective sleepiness, performance, or mood. Caffeine appeared to have had a greater alerting influence on estimates of sleepiness that it did on either mood or performance (25). The ingestion of hypnotics at bed time did not significantly influence the daytime correlations. Amount and quality of nocturnal sleep were not significantly related to subjective daytime sleepiness.

As noted earlier, the expectation that increased sleep tendency would be associated with inadequate sleep was based primarily upon studies which showed that sleep deprivation decreased SL while sleep extension prolonged it. However, our MSLT findings are consistent with the results from an increasing number of studies showing that higher daytime sleep tendency is associated with better nocturnal sleep (12,13,14,15,16) rather than shorter and poorer sleep (8). Carskadon et al. (11) studied the effects of extended sleep following normal and restricted sleep and found that MSLT SL was reduced during extended sleep. A recent report (26), examined the sleep debt hypothesis. These researchers took a group of sleepy subjects (SL  $\leq 6$  min) and a group of alert subjects (SL  $\geq 16$  mins) and extended their sleep period from 8 hrs to 10 hrs for 6 nights. Both groups showed a significant increase in SL during extended sleep. But the daytime sleepy subjects still had shorter SL than the alert group. These results confirmed the earlier finding of Carskadon and Dement (11) that extending sleep reduced daytime sleep tendency but in the Timms et al. study (26) similar increases occurred in the SL of both alert and sleepy subjects and the baseline relationship between alert and sleepy subjects was not changed after sleep extension. In our study, pretreatment SL correlated significantly with average SL during treatment day 1,  $r = .43$ , and day 2,  $r = .33$ , regardless of treatment group. Further, sleep extension may impair, rather than improve, performance. Taub et al. (27) found that extending sleep led to significantly poorer performance on experimenter-paced tasks and no change on subject-paced tasks. Possible causes for this effect are not clear. Carskadon et al. (28) found

that performance on a memory and search task did not vary with extended sleep when compared to either normal and or restricted sleep.

There was a trend toward an association between shorter SL and better mood, but we found no relationship between SL and performance. Seidel et al. (12) found a significant relationship in noncomplaining subjects but not in insomniacs. Roehrs et al. (16) found a difference between alert and sleepy subjects on a divided attention task but not on a longer vigilance task. Sugarman et al. (13) also reported an insignificant correlation between SL and an auditory vigilance task.

Subjective estimates of sleepiness increase with sleep loss, but few studies have reported correlations with performance. It seemed intuitively obvious that with sleep loss one becomes sleepy, performance declines and the two events are related. Glenville and Broughton (17) found such a relationship after one night of sleep loss. However, none was found by Herscovitch and Broughton (18) after five nights of partial sleep loss. They postulated that the relationship between subjective sleepiness and performance might be lost after five nights of partial sleep loss or that the relationship might hold only for more severe sleep loss. Of those two alternatives, we believe the magnitude of sleep loss is more important.

Our most consistent significant finding was the relationship of subjective sleepiness to mood. The more sleepy subjects said they were more tense, confused, fatigued and sad. They were also less calm, had less vigor and felt the tasks required more effort than did more alert subjects. But, it is not surprising that the correlations between subjective estimates of mood and subjective estimates of sleepiness, which is a sort of mood itself, were significant. Perhaps of more importance is the absence of such a relationship between our measure of objective sleepiness and mood. In our subjects, how sleepy one felt was more predictive of mood, and even of performance, than how quickly one fell asleep.

A note of caution is in order before SL is written off as insignificant with respect to daytime performance in nonsleep deprived, nonclinical subjects. While we think of our tapping task, and the 3 sec or greater lapses, as an objective measure of sleepiness akin to the Maintenance of Wakefulness Test (MWT) of Mitler et al. (22) some might consider it a performance task. Short SLs were associated with more lapses. Mitler et al. reported no significant difference in MSLT and MWT SL in their control

subjects. Our 10 minute tapping task was conducted in a low stimulation situation. The subject was sitting up in bed, in a semi sound proof, dimly lit room. Although told to stay awake, the setting and task was conducive to drowsiness. Thus, subjects with greater sleep tendency would appear to have more difficulty in remaining alert in situations where involvement and stimulation are low (29). But the parameters of such involvement and level of stimulation are not clear. Both Sugarman et al. (13) and Roehrs et al. (16) found no significant relationship between SL and performance on a longer vigilance task. Our 4-choice reaction time task, which has been found sensitive to both hypnotic hangover effects and sleep loss, did not differentiate between our short SL and longer SL subjects. More studies are needed to determine what conditions and what types of tasks are sensitive to sleepiness, whether and how these differ for subjective and objective measures of sleepiness, and how the state of the subject influences these relationships. Our results indicate that objective sleepiness was correlated with nocturnal sleep, but subjective sleepiness was not. Subjective sleepiness was related to mood and performance, objective sleepiness was not. We also found that objective sleepiness was significantly decreased by the arousal effects of caffeine, but subjective sleepiness was less improved (25). Caffeine altered the relationship between subjective sleepiness and mood while having no significant influence on the relationship of objective sleepiness to daytime mood or performance.

As both Carskadon and Dement (29) and Broughton (30) have reported, there appears to be more than one type of daytime sleepiness. Broughton differentiated sleepiness with respect to cause, i.e., sleep loss vs pathology, while Carskadon and Dement differentiated sleepiness with respect to type of measurement, MSLT vs SSS. Carskadon and Dement (8) view the MSLT as a measure of physiological sleep tendency in the absence of alerting factors. They suggest that manifest sleep tendency, as measured by the introspective SSS, is more akin to behavioral measures of sleepiness/alertness, and more sensitive to a range of external and motivational factors, and less stable over time. The relationship of our subjective measure to mood and performance supports Carskadon and Dement's concept of the sensitivity of manifest sleep tendency to motivational factors and its relation to behavioral measures. The high reliability of SL over 4-14

months (31) clearly indicates the stability of an individual's sleep tendency.

Should subjects with a stable tendency to fall asleep in less than 5 mins be labeled as pathologically sleepy? We believe that such labeling is not appropriate for subjects such as those in our study. Our subjects with average SL of  $\leq 5$  min meet the criteria for good sleepers, and sleep came easily when given the opportunity to sleep during the day or night. For some, this may have come through training and, for others, it may reflect a stable personal characteristic. These subjects sleep better at night and appear to be more relaxed than subjects who have longer daytime SL and poorer nocturnal sleep. For sleep deprived subjects and patients with disorders of excessive somnolence, these conclusions would be inappropriate. Thus, as it is necessary to have corroborative data before narcolepsy can be diagnosed from the appearance of MSLT sleep onset REMS, more information than SL on one or more MSLT is needed before one can interpret the clinical or behavioral significance of the finding.

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associated with poorer mood and tended to be related to poorer performance.  
Caffeine significantly reduced these relationships. Nocturnal sleep measures  
were not related to subjective estimates of daytime sleepiness.